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MEMORANDUM

Date: January 14, 1998

To: Stein Buer
Mark Cowin

From: Gary Bardini

Subject: **CALFED Phase II Storage and Conveyance Refinement Process Summary**

The CALFED Bay-Delta Program has been developing and analyzing a series of alternatives through an open public process over the last two years. In Phase I, completed in the Fall of 1996, CALFED developed a short list of alternatives. Phase II of the program included a detailed technical analysis of each alternative. This analysis will lead to identification of a preferred Alternative and will be documented be in a Programmatic Environmental Impact Report/Statement (EIR/EIS). Phase III of the program will develop project-level EIR/EIS's for implementation of the preferred alternative.

For Phase II, significant technical work was produced in the storage and conveyance refinement process. These activities include:

- evaluation of general operating parameters through hydrologic and Delta simulation modeling
- evaluation of capacities and dimensions of storage and conveyance components
- technical studies of both environmental and engineering nature
- development of preliminary cost estimates for the storage and conveyance components and common programs
- preliminary evaluations to determine the feasibility of sites for locating the various action items

The foundational work for Phase II began in January 1996. However, the majority of the technical effort began in September 1996. This technical effort focused on 1) hydrologic and Delta simulation modeling, 2) preliminary cost and feasibility studies, and 3) technical studies.

Hydrologic and Delta Simulation Modeling

One of the most fundamental issues of the storage and conveyance refinement process was devising fair and reasonable operation concepts and rules for the CALFED Alternatives. During 1996, CALFED solicited input on proposed operating concepts over a six month period and incorporated them in the range of evaluation. These concepts were defined in a "Storage and Conveyance Alternative Component Refinement Process" document dated September 5, 1996. This document was the catalyst for the Phase II storage and conveyance hydrologic and hydrodynamic modeling activities, which consisted of 1) refining operating concepts and rules, 2) spreadsheet post-processing operation modeling, 3) system operation modeling, and 4) delta hydrodynamic modeling.

Operation Parameters and Plan for Alternatives: Any water resource planning evaluation must be initiated by making some assumption about concepts for diverting, releasing, and allocating water in the system. For a complete evaluation of CALFED alternatives, was necessary to fully explore the interaction of storage and conveyance components as measured by the full range of CALFED goals. Input from the CALFED agencies and stakeholder community as to the appropriate range of operating concepts was integrated into an operation plan for modeling the Alternatives. These initial concepts were defined in a "Storage and Conveyance Alternative Component Refinement Process," document dated September 5, 1996.

A compilation of suggestions from stakeholders for system operating parameters along with a description of the Alternatives for the Programmatic EIR/EIS were presented at the CALFED Storage and Conveyance Workshop on March 20, 1997. This information is documented in the "Status Reports on Technical Studies for the Storage and Conveyance Refinement Process," dated March 20, 1997. Updates on initial spreadsheet post-processing modeling, system operation modeling, and Delta modeling were also included in the status report.

Based on the initial hydrologic and Delta hydrodynamic studies, more refined operating rules were prepared for the Alternatives and described in the "CALFED Bay-Delta Program System Operation Modeling Plan" (Operation Modeling Plan), dated on July 23, 1997. Again, input from the CALFED agencies and stakeholder community was integrated into this plan. The Operation Modeling Plan describes the assumptions for existing conditions, no action and the program alternatives and DWRSIM program modifications necessary to evaluate the alternative components. The operation assumptions in the Operation Modeling Plan were presented at Storage and Conveyance Workshop on June 25, 1997 by CALFED staff.

Spreadsheet Post-Processing Model: Initial evaluations of potential new storage were analyzed using the CALFED Post-Processing Operation Model. This tool was used to do relatively quick evaluations to help guide the overall storage and conveyance study effort. The evaluations included sensitivity analyses of operation parameters and storage capacities for various storage facilities dedicated to environmental water supply benefits and agricultural and urban water supply benefits. The model provided a suitable method for analyzing the general effects of various storage operation rules and goals, identifying critical external constraints, and providing initial refinement to the ranges of storage and conveyance capacities to be considered in more detailed system operation studies.

The initial sensitivity evaluation of operational parameters and storage capacities using the CALFED Post-Processing Operation Model was presented at the Storage and Conveyance Workshop on March 20, 1997 by CALFED staff. This initial information is documented in the "Status Reports on Technical Studies for the Storage and Conveyance Refinement Process" dated March 20, 1997. CALFED completed two reports summarizing the sensitivity of various operation parameters and physical capacities of potential new storage and conveyance facilities using the spreadsheet-based CALFED Post-Processing Model in the following reports:

"Status Report on Technical Studies for the Storage and Conveyance Refinement Process: Evaluation of Upstream Storage and South of Delta Off-Aqueduct Storage Using the CALFED Post-Processing Spreadsheet Operations Model", dated May 9, 1997.

"Status Report on Technical Studies for the Storage and Conveyance Refinement Process: Combined Environmental – Agricultural and Urban Water Supply Evaluation using the CALFED Post-Processing Spreadsheet Operations Model", dated May 12, 1997.

System Operation Modeling: Any new facilities must fit into California's existing water management system. System modeling tools, such as DWRSIM, can be used to explore the effects of new facilities on water supplies, channel flows, and reservoir elevations. DWRSIM is a water accounting model, which estimates the storage and conveyance of water through the system, in accordance with all the concepts and rules devised to protect the Delta, instream flows, and water supplies.

Efforts to model the various potential CALFED storage and conveyance components using DWRSIM began in the fall of 1996 with model programming modifications and preliminary sensitivity studies. This preliminary work considered combinations of the following stoage and conveyance components using DWRSIM Version 8.41 model: 1) dual Delta conveyance - 5,000 cfs and 15,000 cfs isolated facility, 2) Sacramento River tributary offstream surface storage, and 3) south of Delta off-aqueduct surface storage. This initial information was presented at the Storage and Conveyance Workshop on March 20, 1997 by DWR staff. The "Status Reports on Technical Studies for the Storage and Conveyance Refinement Process," dated March 20, 1997 contains the preliminary system operation modeling conducted with the DWRSIM model.

To complete the system operations modeling for the CALFED evaluation of alternatives, additional DWRSIM program modifications and DWRSIM operation studies were needed. CALFED staff prepared a "CALFED Bay-Delta Program Operation Modeling Plan", finalized on July 23, 1997, which characterized the modeling assumptions and program modifications. These activities were conducted by DWR's Hydrology and Operations Section and a CALFED consultant Surface Water Resources, Inc (SWRI), which added new facility components and ERPP flow targets to DWRSIM along with operation studies with specific combinations of storage and conveyance facilities to represent each CALFED alternative.

Two reports titled "A Status Report on System Modeling Using DWRSIM," dated September 24, 1997 and "Preliminary Results/Evaluation of System Modeling with DWRSIM," dated September 23, 1997 were presented by CALFED, DWR, and SWRI at the Storage and Conveyance Workshop on September 24, 1997. The report described 1) the development of 2020-level of development hydrology, 2) the development of new DWRSIM model features, and 3) the preliminary results of the system operation studies. This preliminary work represented combinations of the following alternative components using DWRSIM Version 9.04 model:

- 5,000 cfs Isolated Facility
- Environmental Sacramento River tributary offstream surface storage
- Agricultural/Urban Sacramento River tributary offstream surface storage

- South of Delta off-aqueduct surface storage
- Sacramento Valley and San Joaquin Valley groundwater storage

Following the Storage and Conveyance Workshop on September 24, 1997, DWR and SWRI updated and completed the operation studies described in the operation modeling plan along with some sensitivity studies. CALFED staff held a meeting with stakeholders on October 30, 1997 to inform the stakeholder community of the preliminary results and to develop additional sensitivity criteria for system operation analysis. This information was provided in a report titled "CALFED Bay-Delta Program Storage and Conveyance Refinement Process: A Status Report on System Modeling Using DWRSIM", dated October 30, 1997. This preliminary work represented combinations of the following alternative components using DWRSIM Version 9.06 model:

- 5,000 cfs and 15,000 cfs Isolated Facility
- Environmental Sacramento River tributary offstream surface storage
- Environmental San Joaquin offstream surface storage
- Agricultural/Urban Sacramento River tributary offstream surface storage
- South of Delta off-aqueduct surface storage
- In-Delta surface storage
- Sacramento Valley and San Joaquin Valley groundwater storage

In an effort to refine the CALFED Program Alternatives and recommend a preferred draft alternative, CALFED organized an Interagency Development Team (IDT) in mid-October. Several new operation criteria were devised by IDT to further refine CALFED Program Alternatives and were modeled by DWR and CALFED staff. For predicting the water supply consequences of the alternatives, two operation criteria were analyzed to represent a range of possible operational rules that might be necessary to protect the Delta ecosystem for each alternative. System operation studies were complete both with and without storage being for each alternative.

The preliminary results of the sensitivity studies were presented to the CALFED Policy Group in a presentation package titled "CALFED Bay-Delta Program Water Supply Opportunities: Evaluation of Refined Alternatives" on November 24, 1997. A presentation package on the initial evaluation of the alternatives prior to the IDT effort was also presented to the CALFED Policy Group. This presentation package is titled "CALFED Bay-Delta Program Water Supply Opportunities: Initial Evaluation of Alternatives".

At the Storage and Conveyance Workshop on January 22, 1998, the sensitivity studies conducted for IDT and the CALFED Policy Group were presented. The system operation studies are summarized in a report titled "CALFED Bay-Delta Program Storage and Conveyance Refinement Process: A Status Report on System Modeling Using DWRSIM," dated January 22, 1998.

Delta Simulation Modeling: DWRSIM and the spreadsheet models can only estimate in the broadest terms effects on conditions in the Delta. Delta modeling is required to evaluate the effects of flows, stages, velocities, salinities, particle transport in the Delta due to Delta conveyance configurations and new facilities. As part of this work, Delta modeling with DWRSIM1 and later

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DWRSIM2 were conducted to address various hydrodynamic issues associated with analysis of Delta impacts using computer simulations.

Efforts to model the various potential CALFED Delta conveyance alternatives using DWRDSM1 began in the fall of 1996 with the initial analysis of six Delta conveyance geometry's summarized below:

- Existing Delta Geometry
- Interim South Delta Program Geometry
- North Delta Program Geometry
- North Delta Program with Hood Diversion Geometry
- CUWA Alternative C Geometry
- Chain-of-Lakes Alternative.

The alternative configurations were initially described in the "CALFED Bay-Delta Program Draft Delta Conveyance and Storage Component dated January 30, 1997. This initial information was presented at the Storage and Conveyance Workshop on March 20, 1997 by DWR staff and is included in the "Status Reports on Technical Studies for the Storage and Conveyance Refinement Process" dated March 20, 1997. The report represents the preliminary Delta simulation modeling conducted with the DWRDSM1 model along with preliminary efforts to recalibrate the DWRDSM1 (Suisun Marsh Version) model, using both new velocity and channel geometry data collected by USGS.

Using DWRDSM1, simulations of six of CALFED Delta configuration alternatives were completed and described in a report titled "Status Reports on Technical Studies for Storage and Conveyance Refinement Process: Delta Simulation Model Studies of Alternatives 1A, 1C, 2B, 2D, 2E and 3E", dated August 4, 1997. Additional information is presented in an addendum titled "CALFED Bay-Delta Program Storage and Conveyance Refinement Process: Addendum and Errata to Delta Simulation Model Studies of Alternatives 1A, 1C, 2B, 2D, 2E, 3E", dated September 24, 1997. A summary description of the Delta alternatives configurations are:

- ***Alternative 1A*** – Existing Delta geometry with no changes to any Delta channels or structure
- ***Alternative 1C*** – Delta change consistent with the preferred alternative for the Interim South Delta Program
- ***Alternative 2B*** – North Delta improvements, a 10,000 cfs screened Hood intake, and south Delta improvements
- ***Alternative 2D*** – 10,000 cfs screened Hood intake, eastern Mokelumne River floodway, east Delta habitat, and south Delta habitat
- ***Alternative 2E*** – Tyler Island Habitat, western Mokelumne River floodway, Dead Horse floodway, east Delta habitat, and south Delta habitat.
- ***Alternative 3E*** – 15,000 cfs isolated facility at Hood and joined at Clifton Court Forebay south of Victoria Canal

Deltawide hydraulics and water quality of CALFED alternative 3A and 3B were completed later in a report titled "Status Reports on Technical Studies for Storage and Conveyance Refinement Process: Delta Simulation Model Studies of Alternatives 3A and 3B," dated October 2, 1997. CALFED alternatives 3A and 3B assume a 5,000 cfs isolated facility and South Delta flow control structures. Alternative 3B assumes an in-Delta storage component.

Delta conditions for the CALFED alternatives were simulated by DWRDSM1 using a 16 water year period (1975-91) under a common hydrology from DWRSIM operation study 472B. Study 472B assumed a 1995 level of development and a 2020 level of water demands under the SWRCB 1995 water Quality Control Plan with permit allowing up to 10,300 cfs pumping at Banks Pumping Plant. This 16 period represents a wide range of Delta inflows and export conditions.

Delta modeling results include: flows and velocities, circulation patterns, salinity, and water level in the south Delta. Circulation patterns are presented using average flow directions and mass tracking studies. Salinity is discussed using end of month total dissolved solids and X2 location.

The recalibration of the Delta Simulation Model 1 (Suisun Marsh Version) model by DWR Suisun Marsh Branch was completed in September 1997. A final report titled "Status Reports on Technical Studies for Storage and Conveyance Refinement Process: Recalibration of the Delta simulation Model I (Suisun Marsh Version)," dated September 4, 1997 summarizes the geometry revision base on the latest Delta and Bay bathymetry data, and the DSM1 hydrodynamics and salinity recalibration based on the later flow and salinity data.

In an effort to refine the CALFED Program alternatives, additional Delta simulations were conducted using DWR's new Delta simulation model, DWRDSM2. The Delta simulation model has river, estuary, and land modeling improves described below:

- **River** - Can simulate riverine systems, and has been extended from Sacramento to Shasta Dam. Also has been tested with high flow/stage simulations for flood modeling.
- **Estuary** - Completely flexible estuary model; stages and flows may be specified at boundary and internal points.
- **Land** - Includes effects from land-based processes, such as consumptive use and agricultural runoff.

DWRDSM2 calculates stage, flow, velocities; many mass transport processes, including salts, multiple non-conservative constituents, temperature, THM formation potential and individual particles. Delta alternatives 1A, 1C, 2B, and 3E (modified) were analyzed with DWRDSM2, using DWRSIM-produced Delta hydrologies 516, 531, 532, and 551 respectively. A summary description of the Delta alternatives configurations are:

- ***Alternative IA*** – Existing Delta geometry with no changes to any Delta channels or structure

- ***Alternative 1C*** – Delta change consistent with the preferred alternative for the Interim South Delta Program
- ***Alternative 2B*** – North Delta improvements, a 10,000 cfs screened Hood intake, and south Delta improvements
- ***Alternative 3E (modified)*** – 15,000 cfs isolated facility at Hood and joined at Clifton Court Forebay south of Victoria Canal

Delta conditions for the CALFED alternatives were simulated by DWRDSM2 using a 16 water year period (1975-91). These Delta modeling results are presented with respect to Delta flows, Delta electrical conductivity representing water quality, and water levels in the south Delta. In addition to monthly average electrical conductivity throughout the Delta, the monthly average X2 location for each alternative is presented.

A list of hydrologic and hydrodynamic reports and documents produced during Phase II for the storage and conveyance refinement process is shown in Table 1:

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Table 1 - Hydrologic and Hydrodynamic Modeling Reports and Documents

Reports and Documents
Operation Parameters and Plan for Alternatives
• "Storage and Conveyance Alternative Component Refinement Process" document dated September 5, 1996
• "Status Report on Technical Studies for the Storage and Conveyance Refinement Process" dated March 20, 1997 "- Compilation of suggestions for System Operating Parameters, CALFED Bay-Delta Program Modeling Section and Alternatives for Programmatic EIR/EIS Evaluation Sections.
• "CALFED Bay-Delta Program System Operation Modeling Plan" document dated July 23, 1997
Spreadsheet Post-Processing Operation Models
• "Status Report on Technical Studies for the Storage and Conveyance Refinement Process" dated March 20, 1997 "- Post Processing Operation Model, Initial Results Draft Report.
• "Status Report on Technical Studies for the Storage and Conveyance Refinement Process: Evaluation of Upstream Storage and South of Delta Off-Aqueduct Storage Using the CALFED Post-Processing Spreadsheet Operations Model", dated May 9, 1997.
• "Status Report on Technical Studies for the Storage and Conveyance Refinement Process: Combined Environmental – Agricultural and Urban Water Supply Evaluation using the CALFED Post-Processing Spreadsheet Operations Model", dated May 12, 1997
System Operation Modeling
• "Status Report on Technical Studies for the Storage and Conveyance Refinement Process" dated March 20, 1997 "- System Modeling Studies of CALFED Alternatives using DWRSIM Section.
• "CALFED Bay-Delta Program Storage and Conveyance Refinement Process: A Status Report on System Modeling Using DWRSIM", dated September 24, 1997
• "CALFED Bay-Delta Program Storage and Conveyance Refinement Process: Preliminary Results/Evaluation of System Modeling with DWRSIM", dated September 23, 1997
• "CALFED Bay-Delta Program Storage and Conveyance Refinement Process: A Status Report on System Modeling Using DWRSIM", dated October 30, 1997
• "CALFED Bay-Delta Program Storage and Conveyance Refinement Process: A Status Report on System Modeling Using DWRSIM", dated January 22, 1998
Delta Hydrodynamic Modeling
• "Status Report on Technical Studies for the Storage and Conveyance Refinement Process" dated March 20, 1997 "- Delta Modeling: (a) Model Studies of CALFED Alternatives using DWRDSMI Section, (b) Recalibration of DWRDSM1, Suisun Marsh Version Section
• "CALFED Bay-Delta Program Storage and Conveyance Refinement Process: Delta Simulation Model Studies of Alternatives 1A, 1C, 2B, 2D, 2E, 3E", dated August 4, 1997
• "CALFED Bay-Delta Program Storage and Conveyance Refinement Process: Recalibration of the Delta Simulation Model I (Suisun Marsh Version), dated September 4, 1997
• "CALFED Bay-Delta Program Storage and Conveyance Refinement Process: Addendum and Errata to Delta Simulation Model Studies of Alternatives 1A, 1C, 2B, 2D, 2E, 3E", dated September 24, 1997
• "CALFED Bay-Delta Program Storage and Conveyance Refinement Process: Delta Simulation Model Studies of Alternatives 3A and 3B", dated September 24, 1997
• "CALFED Bay-Delta Program Storage and Conveyance Refinement Process: Delta Simulation Model Studies of Alternatives 1A, 1C, 2B, 3E (modified), dated December 1, 1997"

Preliminary Cost and Feasibility Studies

One of the first objectives of the Storage and Conveyance Refinement Process had been development of inventories of storage and conveyance opportunities. In developing the storage and conveyance component inventories, numerous studies and ongoing investigation were reviewed from the last 40 years by Federal, State and local agencies to ensure that the most appropriate components were included. In particular, information by the Department of Water Resources (DWR) for the Bulletin 160-98 Program (the California Water Plan Update) and the Los Banos Grandes Program were reviewed.

To aid in the initial selection of individual component, first-level selection criteria were developed. The criteria are:

- storage facility must have a minimum new capacity of 100 thousand acre-feet (TAF)
- a conveyance facility must have a minimum new capacity of 500 cubic feet per second (cfs)
- component must not conflict with existing laws, such as projects which would be located on federally designed Wild and Scenic Rivers or within Wilderness Areas
- component has potential to significantly contribute to the Program's objectives

The inventories for surface storage components, groundwater storage components, and conveyance components are described in a report titled "CALFED Bay-Delta Program Storage and Conveyance Component Inventories", dated March 7, 1997. The information was presented at Storage and Conveyance Workshop on March 20, 1997 by CALFED staff.

The inventories report lead to a more refined list of components to be studied in further detail. Twenty-three (23) reports were prepared and compiled into a report titled "CALFED Storage and Conveyance Components Refinement Process," dated October, 1997. The storage and coveyance facilities that were evaluated are listed below:

Surface Storage Facilities
Lake Berryessa Reservoir
Cottonwood Creek Complex
Los Banos Grandes Reservoir
Los Vaqueros Reservoir Enlargement
Millerton Lake Enlargement
Montogomery Reservoir
Orestimba Reservoir
Red Bank Project
San Luis Reservoir Enlargement
Sites/Colusa Reservoir Project
Shasta Lake Enlargement
Thomes-Newville Reservoir

Surface Storage Conveyance
Lake Berryessa Intertie
Chico Landing Intertie
Mid-Valley Canal
Tehama-Colusa Canal Enlargment
Tehama-Colusa Canal Extension

Sacramento-San Joaquin Delta Facilities
Chain of Lakes Project
In-Delta Storage Facilities
Isolated Delta Conveyance Facilities
Multiple Intake Option
Improved Through Delta Conveyance
Western Delta Isolated Conveyance Facility

CALFED is currently in the process of screening the surface water storage locations based on the information of compiled facility inventories and cost estimates. CALFED agency staff with

backgrounds in biology, civil engineering, geology, and hydrology are identifying and eliminating impracticable surface water storage locations. The criteria for eliminating a surface water storage location is 1) inadequate storage volumes, 2) conflicts with CALFED's restoration programs, 3) excessive cost, and 4) engineering constraints. Site locations with high environmental impacts are being "red flagged" as locations with higher mitigation costs.

A list of preliminary cost and feasibility reports produced during Phase II for the storage and conveyance refinement process is shown in Table 2:

Table 2 – Preliminary Cost and Feasibility Reports

Reports and Documents
• "CALFED Bay-Delta Program Storage and Conveyance Component Inventories", dated March 7, 1997
• "CALFED Storage and Conveyance Components Refinement Process," dated October, 1997

Technical Studies

Several technical reports have been completed as part of the storage and conveyance refinement process. Reports on flood control reoperations options with storage created under the CALFED Bay-Delta Program and groundwater use with special emphasis on conjunctive use projects were completed by CALFED.

The New Year's Day Flood of 1997 was probably the largest in the 90-year northern California measured record which begins in 1906. It was notable in the sustained intensity of rainfall, the volume of floodwater and the areal extent – from the Oregon border down to the southern end of the Sierra. New flood records were set on many of the major Central Valley rivers. Immediately following the New Year's Day Flood of 1997, CALFED examined the possibility of transferring flood control space from Shasta Lake and Lake Oroville to new offstream storage being preliminarily investigated. A report titled "Status Report on Technical Studies for the Storage and Conveyance Refinement Process: CVP/SWP Flood Control Reoperation," describes the evaluation using a CVP/SWP spreadsheet model.

Groundwater provides about 40 percent of the urban and agricultural water supply in California. Appropriate and effective groundwater management is essential to the success of CALFED Bay-Delta Program. To this end, CALFED conducted an outreach on groundwater use to help identify and address stakeholder concerns about groundwater use and management with special emphasis on conjunctive use projects. A report titled "Status Report on Technical Studies for the Storage and Conveyance Refinement Process: CALFED Groundwater Outreach Program," dated November 12, 1997 describes the progress of the outreach program. The report discloses the scope of the program, definitions of groundwater terms to help facilitate discussion of groundwater issues, draft principles for CALFED conjunctive use projects, a summary of stakeholder concerns, and preliminary mitigation strategies to address those concerns.

A list of technical reports produced during Phase II for the storage and conveyance refinement process is shown in Table 3:

Table 3 – Technical Reports

Reports and Documents
• "Status Report on Technical Studies for the Storage and Conveyance Refinement Process: CVP/SWP Flood Control Reoperation,"
• Status Report on Technical Studies for the Storage and Conveyance Refinement Process: CALFED Groundwater Outreach Program," dated November 12, 1997